LAS File Processing Using LASTOOLS

LASTOOLS is a set of individual command line tools that process data stored in LAS format. Written by Martin Isenburg, these tools are an efficient way to perform an assortment of conversion, reformatting and data inspection workflows. This document presents a variety of examples and scenarios that show how you can use LASTOOLS to work with the LAS files you download from the Minnesota Geospatial Information Office ftp site at: ftp://ftp.lmic.state.mn.us/pub/data/elevation/lidar.

Contents

LASTOOLS are available at: http://lastools.org
lastools@googlegroups.com

PRELUDE

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I want to start off by stating very clearly that **I DON'T USE AutoCAD,** I'm an ArcMAP monkey. But I have worked with quite a few really great folks who use CAD over the past two years in an effort to help them get LiDAR data into AutoCAD effectively. What I'm presenting below is based on those experiences. There may be better ways to do this and I would be grateful to know what they are. So, if you're reading this thinking…"he doesn't know what he's talking about" I hope you get back to me and set me straight!

Because indeed, I don't really know what I'm talking about☺.

What I have seen in my experience working with CAD techs is that they are most interested in laser shots that have bounced off the ground and not a tree or a building. LiDAR data is a collection of point data and these points are categorized (classified) and assigned a number that represents what they bounced off of. The LiDAR point classifications as defined in the ASPRS LAS Standards are:

- 0 – Created, Never Classified
- 1 – Unclassified
- 2 – Ground
- 3 – Low Vegetation
- 4 – Medium Vegetation
- 5 – High Vegetation
- 6 – Buildings
- 7 –Low Point (Noise)
- 8 – Model Key-Point
- 9 – Water
- 10 – Reserved
- 11 – Reserved
- 12 – Overlap

Not all LAS files are categorized to the full extent of this set of classifications. In many cases there are only class 2 and 1. In others there are more. It just depends on the purpose of the LiDAR flight and what was contracted to be done by the vendor. For the data in your county we've got classes 1, 2, 4 (all vegetation), 6, 7, 8, 9, 10, and 12.

The categories most important to those individuals that are using CAD or GIS software to model the ground should be most interested in categories 2 (ground) and 8 (model key-point). Model Key-Points represent a subset of the Ground points that have been filtered to identify those points that are required to build a surface capable of producing two foot contours. You'll lose some detail for sure by weeding out these points, but the contours created are "statistically" valid at the 95% confidence level.

There are so many ground points that many CAD systems have a tough time dealing with points over a moderately sized area but it varies a lot because folks have different versions of the software and hardware with different capabilities. The latest versions of AutoCAD have been tweaked to be able to

handle larger LiDAR derived data and new machines have more RAM and 64-bit operating system also play a part.

The following sections describe a variety of LiDAR Use Cases that I have seen. I'm adding to this document on a regular basis as new Use Cases surface.

I hope you find this information useful and I appreciate any feedback that you might have on making this document more useful.

The most current version of this document can be downloaded from ftp://ftp.lmic.state.mn.us/pub/data/elevation/lidar/tools/lastools/LAS_File_Processing_Using_LASTOOLS.PDF.

GETTING STARTED

LASTOOLS is a set of command line tools that perform a wide variety of processing methods on LAS formatted files.

LASTOOLS are available at: http://lastools.org

And there is a community of discussion at lastools@googlegropus.com

ONLY PORTIONS OF THESE TOOLS ARE AVAILABLE FOR FREE. PLEASE READ THE LICENSING DOCUMENTS. ALL OF THE TOOLS REFERENCED IN THIS DOCUMENT ARE AVAILABLE TO USE FOR FREE. (LASINFO, LASZIP, LAS2LAS, LAS2TXT).

Please consult the link http://lastools.org/download/LICENSE.txt for a listing of the tools and their licensing requirements.

Each tool can be downloaded individually or they can be downloaded as an entire set in a zip file. There is no installation routine, if you are using Windows you simply unzip the files to a folder on your hard drive, open a command window and run the commands.

I suggest that you unzip LASTOOLS to your C:\ drive and don't put in a folder that has a space in the name. Simply taking the default and unzipping to the C:\ folder will result in a folder named "C:\LASTOOLS" and make sure you retain the folders that are included in the zip file. Unzipping will create a number of folders in this directory. All of the executable programs are stored in a folder named "*c:\lastools\bin*".

It's helpful to add the BIN folder to your system PATH environment variable (*c:\lastools\bin*). Consult your windows documentation on how to access and modify environment variables. Once you add the folder to your path statement you can call the programs that exist in this folder by name and don't have to enter the entire path to run them.

What can I do with LASTOOLS? There is a complete listing of the tools in the bin folder and a _README.TXT file with each of the tools. You'll have to sort through these yourself to find out all that LASTOOLS can do but here's a few examples:

- Project LAS files
- Set the projection in the LAS/LAZ file header
- Convert LAS files to a variety of formats including:
  - Shapefiles
  - ASCII files
- Filter points based on a variety of properties including:
  - Classification
  - Return
  - Scan Angle
  - Bounding Box
- Generate DEMs from LAS Files using any of the filtering options
- Generate Rasters where the cell values represent the number of points that fall within the cell.
- Export a LAS file to an X,Y,Z file TXT file that can be read into CAD systems
- Generate a shapefile that represents the boundary of data within a LAS file
- Compress LAS files up to 10 times turning a 400 megabyte LAS file into a 40 megabyte LAZ file

LASTOOLS also contains a toolbox for ArcGIS Versions 9.3+.

CURL

CURL is an Open Source tool (http://curl.haxx.se/) that provides the capability to download resources from URL and FTP based sources. This tool provides the capacity to download data from the internet and feed the files into processing software. Like LASTOOLS, CURL is a command line tool that is run via a system Command Prompt.

What does this mean for LASTOOLS? This means that you can remove the download step and use LASTOOLS to process files as they are being retrieved by CURL. Instead of specifying a file to process you use the *–stdin* switch in LASTOOLS to process the data stream coming in from the standard input. When used in conjunction with CURL you can download and process all at the same time.

This functionality is a time and disk-space saver because it can "hide" the time required for compression or decompression of LAS/LAZ by doing it simultaneously while the file is downloading and avoid having to store a compressed (or uncompressed) copy.

All LASTOOLS functions and switches can utilize this technique and most of the examples listed below will include a CURL example.

WORKING WITH MINNESOTA LAS/LAZ DATA

When you download data from the Minnesota LiDAR ftp site (ftp.lmic.state.mn.us) the original LAS file has been compressed to LAZ format using **LASTOOLS | LASZIP**. If you are using **LASTOOLS**, you don't need to unzip them because LASTOOLS will operate on compressed files. But if your intent is to use the LAS files in some other software that cannot read LAZ compressed files you'll need to uncompress them. To do this use the **LASZIP** tool in the following way.

NOTE: I've got one LAZ file named 4310-07-50.laz stored in a folder named D:\dems

1) Open a Command Dialog box (**START | PROGRAMS | ACCESSORIES | Command Prompt**)
   a. This opens a command window – like the one shown below.
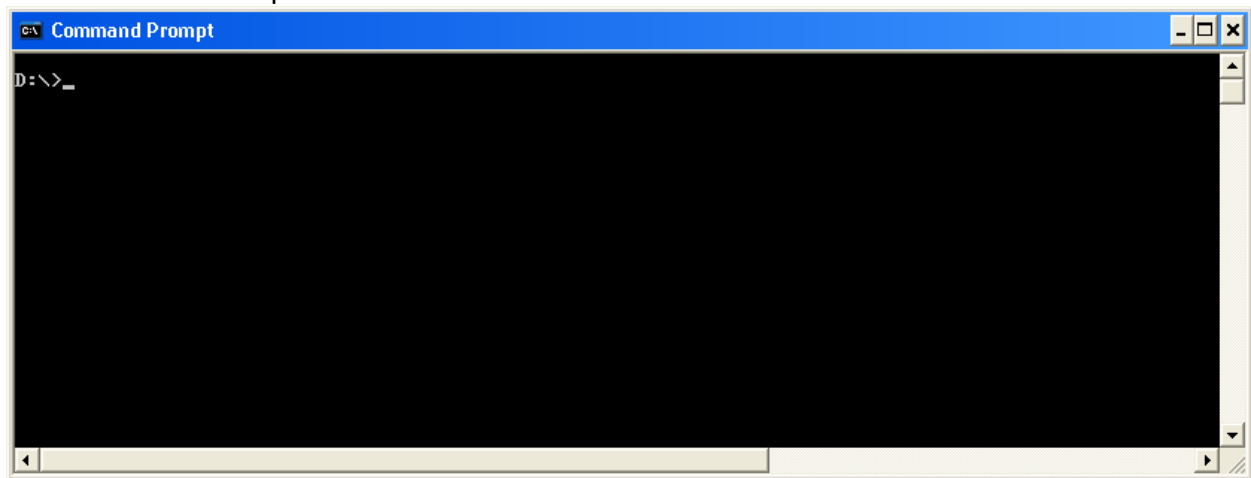
   b. I have my data stored in a folder called D:\DEMS. So, the first thing I'm going to do is change directories using the CD DEMs command

   D:\> cd \dems

   c. To unzip the LAZ file I'll use the LASZIP command and the wildcard to unzip all of the files in this folder even though I have only one. This will unzip the LAZ file and create a LAS file with the same name as shown below.

   D:\DEMS> laszip –v –i *.laz

   d. This will unzip all of the LAZ files in the folder (-i *.laz) and display all messages (-v).

LISTING THE PROPERTIES OF A LAS/LAZ FILE

The LASINFO tool is used to read a LAS/LAZ file and list the contents, including the variable length headers and listing the various attributes of the LAS file. To list the file contents to the screen use the following command:

C:\DEMS> LASINFO –i 4310-06-50.LAZ

To save the output in a text file use the following command:

C:\DEMS> LASINFO –i 4310-07-50.LAZ –o 4310-07-50-INFO.TXT

Notice for this LAZ file the following classifications and point numbers:

```
histogram of classification of points:
  5608568 Unclassified (1)
  5113094 Ground (2)
  1195024 Medium Vegetation (4)
    63216 Building (6)
       62 Low Point (noise) (7)
   186192 Model Key-point (mass point) (8)
      979 Water (9)
      357 Reserved for ASPRS Definition (10)
```

Using CURL :

C:\DEMS> CURL –s ftp:// [ftp.lmic.state.mn.us/pub/data/elevation/lidar /county/yellowmedicine/laz/4310-07-50.laz](ftp.lmic.state.mn.us/pub/data/elevation/lidar/county/yellowmedicine/laz/4310-07-50.laz) | LASINFO -stdin

EXPORTING LAS/LAZ FILES TO ASCII X,Y,Z FORMATTED FILES

Many software programs cannot ingest LAS/LAZ files, so they must first be converted to some neutral format – often times an ascii files with x y z values separated by commas. LASTOOLS has this capability in the LAS2TXT command. It's got a number of different parameters that you can control including the order you want to store the values, the separator (comma vs semi-colon or spaces), filter out specific classifications, coordinate windows and much more.

Let's assume that we want to get bare-earth points from a LAS file into a text file that has the X Y and Z values in that order separated by commas. Bare earth points have classification value #2 and there is also a Mass Point class that is a reduced set of points that is classification #8.

In this example we'll create two outputs, one with classifications 2 and 8 and one with only class 8.

Start by creating the output file with all of the bare earth points using the following command:

D:\DEMS> LAS2TXT –i 4310-07-50.LAZ –o 4310-07-50_BE.TXT –parse xyz –sep comma –keep_class 2 8

Based on the histogram of points listed above, there should be 5,113,094 + 186,192 = 5,299,286 points in the output file.

Next we'll create an output file that has just the Mass Points in them. This output will contain many fewer points than the first one. Use the command line:

LAS2TXT –i 4310-07-50.LAZ –O 4310-07-50_MP.TXT –parse xyz –sep comma –keep_class 8

Based on the histogram of points listed above, there should be 186,192 points in the output file.

Curl Example

CURL –s ftp:// ftp.lmic.state.mn.us/pub/data/elevation/lidar /county/yellowmedicine/laz/4310-07-50.laz | LAS2TXT–stdin -o 4310-07-50_MP.TXT -parse xyz –sep comma –keep_class 8

SUBSETTING (CLIPPING) LAS/LAZ Files

In some circumstances you don't need to work with the entire tile's worth of data. LASTOOLS has command line options to subset data based on coordinates. This is done using the –CLIP options:

    -CLIP_CIRCLE x y radius
    -CLIP Min_x Min_y Max_x Max_y

Taking the above example where we are creating an ASCII output file we can clip the output using the following command lines:

Clipping on an extent
LAS2TXT –i 4310-07-50.LAZ –o 4310-07-50_MP.TXT –parse xyz –sep comma –keep_class 8 –CLIP 345465 4889562 346135 4890188

Clipping on a circle
LAS2TXT –i 4310-07-50.LAZ –o 4310-07-50_MP.TXT –parse xyz –sep comma –keep_class 8 –clip_circle 345465 4889562 500

CURL Examples:

Clipping on an extent
CURL –s ftp://ftp.lmic.state.mn.us/pub/data/elevation/lidar/county/yellowmedicine/laz/4310-07-50.laz | LAS2TXT–stdin –o 4310-07-50_MP.TXT –parse xyz –sep comma –keep_class 8 –clip 345465 4889562 346135 4890188

Clipping on a circle
CURL –s ftp:// ftp.lmic.state.mn.us/pub/data/elevation/lidar /county/yellowmedicine/laz/4310-07-50.laz | LAS2TXT–stdin -o 4310-07-50_MP.TXT -parse xyz –sep comma –keep_class 8 clip_circle 345465 4889562 500

MERGING TILES of LAS/LAZ FILES

The Minnesota elevation mapping project tiles cover an area of about 3.25 square miles. It is Yeager's 4th Law of GIS that the "location of your project maximizes the number of data tiles". That is, your project area will fall across tile boundaries.

Well – LASTOOLS has a switch for that too. It's the **–merged** switch. Let's say you've found that your project area is in two tiles and you've downloaded those two LAZ files to your working folder. You can convert them to comma separated files (-sep comma), xyz order (-parse xyz) filtering out the mass points (-keep_class 8) and clipping if you want to (–clip minx miny maxx maxy). The way to get this done is to use the wildcard "*" sign.

LAS2TXT –i *.LAZ –o OUTPUT.CSV –parse xyz –sep comma –keep_class 8 –merged

This will output a single comma separated file that contains all of the mass points from all the LAZ files found in the folder.

The next example shows how to clip across tiles

LAS2TXT –i *.LAZ –o OUTPUT.CSV –parse xyz –sep comma –keep_class 8 –clip_circle 345465 4889562 1500 –merged

PROJECTING LAS/LAZ FILES TO COUNTY COORDINATES

All LiDAR data downloaded form the LiDAR ftp site is referenced to the State Standard projection, UTM Zone 15, NAD83 Datum (horizontal), NAVD88 (vertical). Many county GIS and CAD programs use the Minnesota County Coordinate System as the horizontal reference for data use within the county. Thus, the data needs to be projected from UTM to the appropriate county coordinate system prior to use.

Fortunately, LASTOOLS can handle this as well using the LAS2LAS tool. This tool has the capability to perform a wide variety of processing tasks on LAS/LAZ files with LAS/LAZ being the output.

In this example, we'll use LAS2LAS to project a LAZ file from UTM to Brown County Coordinates. There is a bit of information that you have to know prior to doing this projection. For Brown county the parameters are as follows:

Projection	Lambert Conic Conformal
False Easting	500000
False Northing	100000
Horizontal Units	Feet
Latitude of Origin	44.108055555555559
Central Meridian	-94.733333333333334

Standard Parallel 1	44.166666666666657
Standard Parallel 2	44.466666666666669
Ellipsoid:	NAD83
Elevation Units:	Feet

The important command line options in this tool are:
- -i = input file name
- -o = output file name
- -target_lcc = output lambert conic conformal projection followed by projection parameters
- -target_feet = output horizontal units are feet
- -target_elevation_feet = output units of feet

To project all of the points in the LAS file use the following command:

D:\> las2las –i 4326-28-35.laz –o 4326-28-35_brown.laz –target_lcc 500000 100000 feet 44.108055555555559 -94.733333333333334 44.166666666666657 44.466666666666669 target_feet -target_elevation_feet

To project only the bare earth and mass points use the following command:

D:\> las2las –i 4326-28-35.laz –o 4326-28-35_brown.laz -target_lcc 500000 100000 feet 44.108055555555559 -94.733333333333334 44.166666666666657 44.466666666666669 -target_feet target_elevation_feet -keep_class 2 8

To project only the mass points use the following command:

D:\> las2las –i 4326-28-35.laz –o 4326-28-35_brown.laz meter -target_lcc 500000 100000 feet 44.108055555555559 -94.733333333333334 44.166666666666657 44.466666666666669 -target_feet -target_elevation_feet -keep_class 8

To project all the LAS files in the folder to LAS files use the following command:

*D:\> las2las –i *.laz –o *.las meter -target_lcc 500000 100000 feet 44.108055555555559 -94.733333333333334 44.166666666666657 44.466666666666669 -target_feet -target_elevation_feet*

For a complete listing of the various county coordinate systems in the state refer to the MnDOT web site at: http://www.dot.state.mn.us/surveying/ToolsTech/mapproj.html

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SCALING X, Y AND Z COORDINATES TO FEET (but not changing the projection)

Most of the LASTOOLS can scale the x, y, and/or z coordinates when processing LAS/LAZ files. A common reason for doing this is when importing into CAD files and the operator would like to work in Feet vs Meters. Since the Minnesota Data is projected to UTM Zone 15 and the horizontal and vertical units are meters this requirement is fairly common when using in a CAD system.

There are three switches to consider:

- -scale_x <scale_factor>
- -scale_y <scale_factor>
- -scale_z <scale_factor>

An example of where you might use this is when converting from a LAS/LAZ file to an ASCII (text) file in X,Y,Z format. Let's expand on the example listed earlier.

The original command:
LAS2TXT –i 4310-07-50.LAZ –o 4310-07-50_BE.TXT –parse xyz –sep comma –keep_class 2 8

Will create a file called 4310-07-05_BE.TXT that contains only points with a classification of 8 formatted in the order xyz and separated by commas. To scale the X, Y, and Z values we would add the following:

LAS2TXT –i 4310-07-50.LAZ –o 4310-07-50_BE.TXT –parse xyz –sep comma –keep_class 2 8 –scale_x 3.28083 –scale_y 3.28083 –scale_z 3.280823

Using CURL

CURL –s ftp://ftp.lmic.state.mn.us/pub/data/elevation/lidar/county/yellowmedicine/laz/4310-07-50.laz | LAS2TXT –stdin –o 4310-07-50_BE.TXT –parse xyz –sep comma –keep_class 2 8 –scale_x 3.28083 –scale_y 3.28083 –scale_z 3.280823

USING CURL WITH LASTOOLS. An alternative to downloading data

CURL is an Open Source tool (http://curl.haxx.se/) that provides the capability to download resources from URL and FTP based sources. This tool provides the capacity to download data from the internet and feed the files into processing software. Like LASTOOLS, CURL is a command line tool that is run via a system Command Prompt.

What does this mean for LASTOOLS? This means that you can remove the download step and use LASTOOLS to process files as they are being retrieved by CURL. Instead of specifying a file to process you use the *–stdin* switch in LASTOOLS to process the data stream coming in from the standard input. When used in conjunction with CURL you can download and process all at the same time.

Going back to the example used previously to create an ASCII file of X,Y,Z values we used the command line:

LAS2TXT –i 4310-07-50.LAZ –o 4310-07-50_MP.TXT –parse xyz –sep comma –keep_class 8

This assumes that we have previously downloaded the LAZ file 4310-07-50.LAZ from
ftp://ftp.lmic.state.mn.us/pub/data/elevation/lidar/county/yellowmedicine/laz

Using CURL we can download and process at the same time. So the above command turns into:

CURL –s ftp://ftp.lmic.state.mn.us/pub/data/elevation/lidar/county/yellowmedicine/laz/4310-07-50.laz | LAS2TXT–stdin -o 4310-07-50_MP.TXT -parse xyz –sep comma –keep_class 8

What happens here is that CURL finds the file on the internet address, downloads the file to the standard input, then pipes the input stream to LASTOOLS which is directed to get the data from the standard input (-stdin).

You can also use this same technique to get a listing of the LAZ file contents using LASINFO in the following way:

CURL –s ftp://ftp.lmic.state.mn.us/pub/data/elevation/lidar/county/yellowmedicine/laz/4310-07-50.laz | LASINFO –stdin

This functionality is a time and disk-space saver because it can "hide" the time required for compression or decompression of LAS/LAZ by doing it simultaneously while the file is downloading and avoid having to store a compressed (or uncompressed) copy.

All LASTOOLS functions and switches can utilize this technique.